High-dimensional asset pricing and portfolio optimization

Valorization

"The improvement of understanding is for two ends: first, our own increase of knowledge; secondly, to enable us to deliver that knowledge to others."
- John Locke (1632-1704)

The research presented herein is about empirical methodology for asset pricing and portfolio management. Within this broad economic context I have pursued a particular focus on issues of portfolio variance reduction, macroeconomic risk factor assessment and financial liquidity risk. These topics are fundamental within the context of academic financial research, but they are also relevant for professionals in the financial sector as well as regulators and supervisory agencies. In this addendum I will attempt to frame and provide examples of the relevance from both of these perspectives. I present this through both the methodological implications of my work and what my empirical findings indicate.

The economic content that unifies the chapters of this thesis is different notions of financial risk. In particular I have studied three facets of risk; (1) macroeconomic risk, (2) liquidity risk and (3) co-movement and financial connectivity. The econometric content that ties together the applications is the challenge of estimating relations between many co-varying variables within very large systems. Thus the methodology proposed is tailored to handle circumstances where either (1) the risk relations are very complicated or (2) the number of financial variables is very large. To achieve this I explore in what manner methods from machine learning and high-dimensional statistics can augment traditional econometric techniques. As such, in the most general sense, these approaches offer opportunities to explore economic issues utilizing more data than was previously possible.

Macroeconomic risk and Portfolio volatility

At the core of portfolio optimization is the trade-off between risk and expected returns. With respect to the financial sector the economic relevance of this thesis can be recognized through two contributions. First is through the methodology developed for portfolio volatility reduction. Standard methods of minimum variance allocation quickly deteriorates when the number of assets in a portfolio grows large. The method I propose in chapter 3 is well suited to handle portfolios with a potentially very large number of assets. This means that even very large financial portfolios can be made more stable than was previously possible with standard econometric tools. The second contribution I would highlight is the approach proposed to assess and compare models of economic risk. There is a wealth of theory to describe sources of macroeconomic risk. The method presented in chapter 2 is well suited to assess the relative fit of the respective theoretical models even for a large number of assets where traditional econometrics methods would be ill-suited.

Apart from the relevance of these methodological contribution several empirically important results stand out. For example, that liquidity risk associated with price sensitivity is very prevalent among assets with low market capitalization. From an investment perspective this finding takes the form of a return premium, which can be the basis for a multitude of trading strategies.

With regards to the econometrics presented herein, both finance professionals and economic consultancies have been exploring methods of machine learning and deep learning to optimize consumer products, marketing and pricing. In these sectors the utilization of large amounts of data is a topic that has been a leading frontier for prediction and forecasting. By nesting these methods in an economic and econometric framework this thesis can help move these applications one step closer to our economic questions beyond prediction. The virtue of this is that statistical regularization and high-dimensional statistics do not have to be substitutes to economic models. Rather, it appears that these methods can be mutually beneficial.

Financial stability and co-movement

Beyond the financial sector, both regulatory authorities and supervisory agencies continuously monitor the financial systems risk exposure to maintain stability. While writing this section, the international financial regulatory framework Basel III is under implementation. Among the pillars of the new framework is the regulation of the ratio of liquid assets to the total flow of liquidity within a financial institution. A critical element for the prospects of this regulation is the precision of the empirical measures of financial liquidity. Chapter 4 of this thesis approaches this issue of financial liquidity and expands upon some of the prominent measures.

Regulators that monitor the stability of the financial system also require a thorough picture of what economic factors are critical for the financial markets and its major institutions. The same methodology proposed herein for portfolio allocation can be applied to understand financial connectivity and spillovers. Whereas is it practical and common to rely on *ad hoc* identification of the paramount institutions or financial groupings, the methods presented in chapter 3 and 4 introduces a data-driven manner to complement the economic models regulators rely on. An example of how this might take shape is through the perspective of financial liquidity. Many of the prominent measures of financial liquidity omit effects of contemporaneous incidents on financial markets. This means that liquidity such

that it is regulated may not be properly reflective of ease of trade when markets are in crisis. Using tools we have explored it is possible to augment these measures to make them more adaptable to times of financial distress.

Furthermore, chapter 2 introduces a methodology to compare what sources of macroeconomic risk are most predictive of price adjustments. Thus, this offers an opportunity to predict which factors financial markets are most sensitive to. In turn, this can be used to classify and compare different sources of risk when monitoring the financial system.

In sum

The research presented in this thesis is relevant for both professionals in the financial sector and regulators. The relevance is related to the monitoring and management of different facets of financial risk. The prospects involve lower portfolio volatility and more precise measures of financial risk. It achieves this through the application of methods that draw upon advancements in other academic disciplines. Approaching traditional economic topics with a novel empirical approach can reveal new aspects to traditional economic phenomena. Whether the methods I have explored will contribute to such a new perspective remains to be determined.

This framing of research in terms of its immediate applicability and relevance outside of academia yet this might not render a complete reflection of the impact of the work. Academia is an important institution to critically assess what we believe to be true and to educate. We do this both through our research and through teaching. My education as a Ph.D. has also contributed to the education of many undergraduate students. Economics is to a great extent an empirical social science and the role of tutors and lecturers teaching empirical methodology is particularly important. The relevance of my research therefore partially extends to the degree with which my understanding helped form more critical and empirically well-versed economists.